PRINCIPLES AND PRACTICES MANUAL FOR ENHANCED ANAEROBIC BIOREMEDIATION

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Introduction

Chlorinated solvents in ground water, primarily trichloroethene (TCE) and perchloroethene (PCE) and their anaerobic degradation daughter products, continue to pose a significant technical and costly challenge to the Department of Defense (DoD). Since 1993, the Air Force Center for Environmental Excellence, Technology Transfer Division (AFCEE/ERT) has been teaming with industry, academia, and the EPA to address this formidable problem. AFCEE/ERT has funded extensive research and demonstration work across the nation to better understand and document the mechanisms responsible for the natural breakdown of these contaminates in the environment. This leading-edge work was documented in the EPA's *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water*, (Sep, 1998). This work, together with that of numerous institutions and research organizations, has resulted in an understanding of the mechanisms and processes responsible for the breakdown of these compounds that was not at all understood only a decade ago.

Although much has been learned there is still much to understand regarding the incomplete mineralization of these relatively recalcitrant compounds. We now understand that the primary mechanism for the breakdown of PCE and TCE is anaerobic reductive dechlorination or halorespiration. This mechanism, simply put, is the replacement of chlorine ions with hydrogen ions that are produced from the fermentation of a natural or manmade organic substrate. This reductive dechlorination process is biologically mediated and fully dependent on favorable environmental conditions and the presence of organisms capable of completing the reductive dechlorination process.

The nation-wide natural attenuation initiative work sponsored by AFCEE has highlighted the various types of plume behavior where some demonstrate complete dechlorination and others show little or no dechlorination. Because of the understanding regarding the importance of adequate organic carbon for fermentation and also the correct microbial communities, several vendors have started offering various organic amendments and/or microbial inoculants to stimulate the complete dechlorination at sites that are stalled at some daughter product such as cis-1,2 dichloroethene (DCE) or vinyl chloride (VC).

Unfortunately, the research has not advanced to the point that one can easily determine: 1) which organic substrate to add or if it makes a difference; 2) if you add a best substrate will the site eventually completely dechlorinate or will it stop or stall at a daughter product; 3) if there is adequate substrate present will the native microbial community be adequate to facilitate complete dechlorination or will a microbial injection be necessary to augment the site; and 4) does a particular site favor a particular substrate and/or microorganism and how do you tell? With vendors offering different substrates or inoculants, it is very difficult for the Air Force project manager to know what to do. To this end, AFCEE/ERT has embarked on another leading-edge program to attempt to answer these difficult but very important questions. These issues will be addressed in the *Principles and Practices Manual for Enhanced Anaerobic Bioremediation.*

Methods

Although AFCEE is funding this new initiative, the *Principles and Practices Manual for Enhanced Anaerobic Bioremediation* will be a Tri-Service (DoD) Manual produced under the direction of representatives from the Air

Force (Jim Gonzales and Jerry Hansen – AFCEE), Navy (Bryan Harre – NFESC), Army (Wayne Sisk – USAEC), and the Environmental Security Technology Certification Program (Andrea Leeson – ESTCP). This DoD board will have conflict of interest free (COI) advisors, namely Patrick Haas (Mitretek) and Cliff Casey (NAVFAC). Parsons will produce the final document with input from major vendors involved in this technology including: Arcadis Geraghty & Miller, Geosyntec, Inc., Groundwater Services, Inc., Northwind Environmental, Regenesis, Inc., and Solutions IES/Terra Systems. A review committee of highly respected experts has been established to oversee and review the manual. Members of the review committee include: Rob Hinchee – chair (Battelle), Paul Johnson (Arizona State Univ), Lewis Semprini (Oregon State Univ), Paul Hadley (Cal DTSC) and Greg Sayles (EPA).

This project was initiated with a meeting of all team members where objectives and tasking were finalized. A final manual outline was debated and agreed upon. The manual will address and attempt to resolve the disagreements in the professional community with regards to the technology. These issues are wide ranging and include such things as: site selection criteria, design methodology, regulator acceptance and permitting, interphase mass transfer, DNAPL remediation, hydrogeology, microbiology, geochemistry, secondary degradation of groundwater quality, and production of noxious gases.

Discussion

The overall and challenging goal of this document is to reach consensus among the sponsors, advisors, authors, major vendors, and the review committee with regards to the questions posed above, with the overall goal of providing a clear path forward for DoD managers considering the use of this new and innovative technology.

References

Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water. EPA/600/R-98/128, September, 1998.

A Treatability Test for Evaluating the Potential Applicability of the Reductive Anaerobic Biological In Situ Treatment Technology (RABITT) to Remediate Chloroethenes, ESTCP, February, 1998